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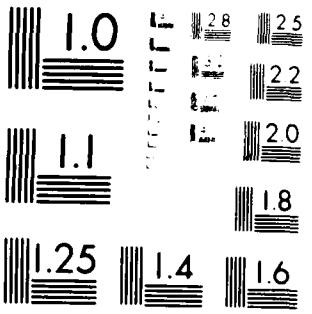

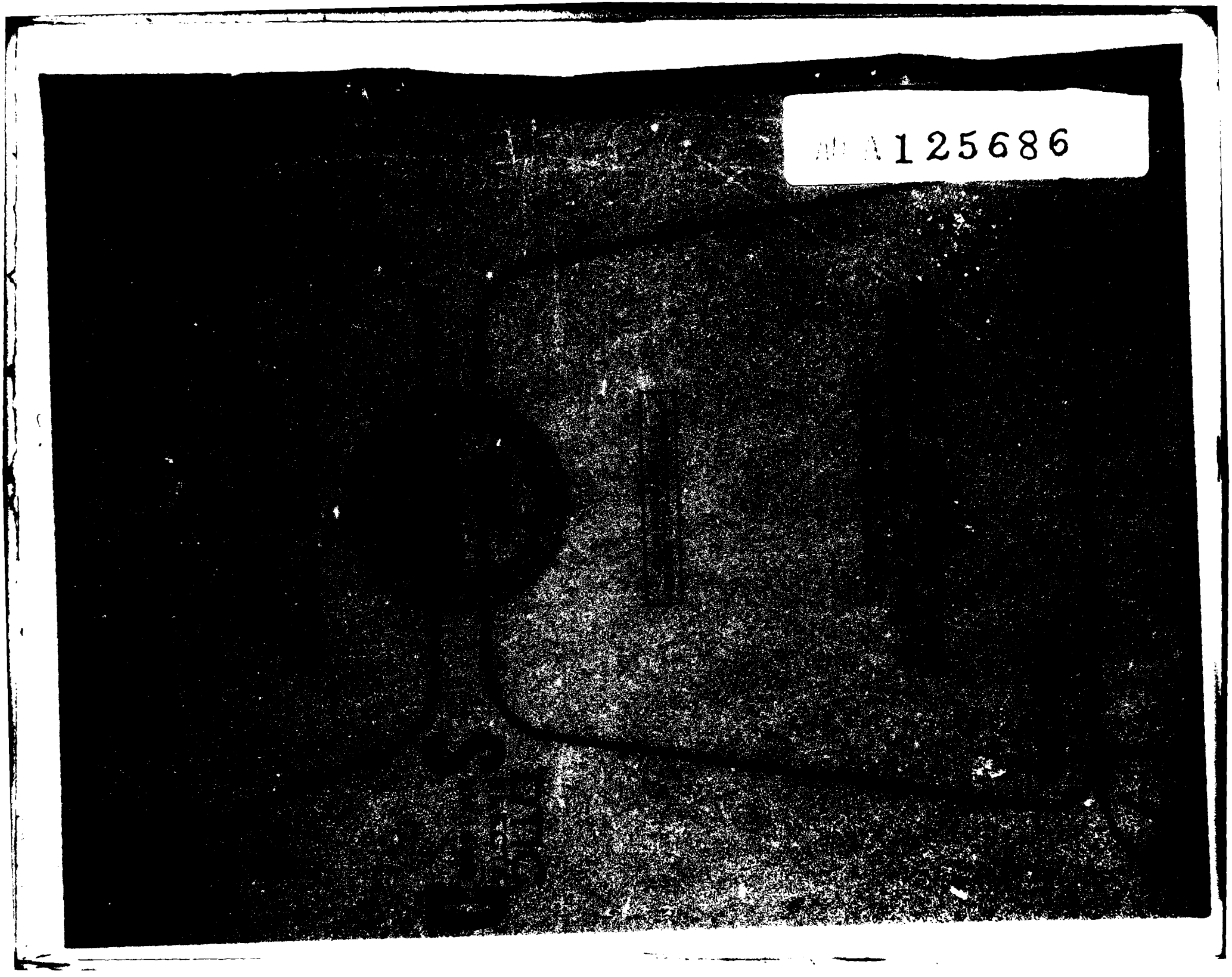

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PREDICTORS OF PERFORMANCE IN NAVY ELECTRONICS SKILLS: THE EFFECT OF MATHEMATICAL SKILLS

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This effort is part of a project designed to identify mathematical requirements relevant to Navy electronics training. The relationship between mathematics ability and electronics performance in the Navy's Basic Electricity and Electronics (BE/E), Class "A," and Class "C" schools was examined to identify the mathematics skills required to complete Navy electronics training successfully and function adequately in electronics maintenance in the fleet. School performance measures were correlated with various

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predictor measures, and variables were analyzed to determine how they clustered together. Results showed that skills in mathematics knowledge are strongly related to success in electronics schools.

FOREWORD

This research and development was conducted under exploratory development task area ZF63.522.011 (Assessment and Enhancement of Prerequisite Skills), work unit 522.011.03.02 (Enhancement of Computational Capabilities), and was sponsored by the Chief of Naval Operations (OP-01). The objectives of the work unit are to identify mathematical skill deficiencies and to develop instructional strategies to improve the efficiency and job relevance of Navy electronics training.

This report is the sixth and final in a series designed to identify mathematical requirements relevant to electronics training. Previous reports described the mathematical skills required for successful performance in Navy electronics Class "A" schools, the mathematics skill levels of entering and graduating "A" school students, the mathematics requirements and performance levels in the Navy's Basic Electricity and Electronics (BE/E) school, the mathematical requirements in the Navy's Class "C" schools, and the mathematical requirements of electronics ratings in the job environment (NPRDC TRs 81-4, 82-2, 82-3, 82-4 and 82-5). The purpose of the current effort was to examine the relationship between mathematics ability and electronics school performance and offer recommendations for curriculum revision. These reports are intended primarily for use by the Chief of Naval Technical Training.

JAMES F. KELLY, JR.
Commanding Officer

JAMES W. TWEEDDALE
Technical Director

SUMMARY

Problem and Background

The sophistication of military equipment is increasing while training budgets remain constrained. Thus, to assure cost-effective training, those skills and knowledges that are essential for successful job performance in the fleet, as well as the subordinate skills and knowledges that enable the trainee to master essential skills, must be identified. Conversely, those skills and knowledges not required for successful performance must be identified and removed from entrance standards and course objectives. To address this problem, the Navy Personnel Research and Development Center (NAVPERSRANDCEN) is conducting a project designed to identify mathematical requirements relevant to electronics training. Previous reports issued concerning this project described the skills required to perform successfully in Navy electronics "A" schools, the mathematics skill levels of entering and graduating "A" school students, the skills required to perform successfully in the Navy's Basic Electricity and Electronics (BE/E) schools and in the Navy's "C" schools, and mathematics requirements of electronics ratings in the job environment.

Objective

The purposes of this effort were to (1) examine the relationship between mathematics ability and electronics school performance and (2) specify the mathematics skills required to complete Navy electronics training successfully and function adequately in electronics maintenance in the fleet.

Approach

Separate analyses were conducted for the BE/E, Class "A", and Class "C" schools. School performance measures were first intercorrelated with various predictor measures. Cluster analyses were then performed to determine empirically how the variables grouped together. The squared multiple correlations of the predictor clusters with each of the criterion variables were then computed.

Findings

BE/E Schools

1. Correlations obtained between the BE/E final and all predictors, except for the Armed Services Vocational Aptitude Battery (ASVAB) word knowledge (WK) subtest score, were statistically significant.

2. Score of the electronics information (EI), mechanical comprehension (MC), and mathematics knowledge (MK) ASVAB subtests were all better predictors of BE/E course performance than was the score of the arithmetic reasoning (AR) ASVAB subtest.

3. The mathematics and electronics predictor clusters each contributed approximately 16 percent of the variance in the BE/E final exam score, while the verbal and arithmetic reasoning clusters contributed only 7 and 5 percent respectively.

4. None of the predictor variables accounted for a significant portion of the variance of BE/E time in course.

Class "A" Schools

1. The NAVPERSRANDCEN "A" school math test score had more and higher correlations with the Class "A" school criterion measures than did any of the other predictor variables.

2. In five of the 10 "A" schools studied (AE, CE Port Hueneme, ET, FT, and GM), the mathematics predictor cluster accounted for most of the accountable variance in the written school measures. In three of these schools, it also represented most of the accountable variance with practical measures.

3. The electronics predictor cluster accounted for most of the attributable variance in the AV, CE Gulfport, DS, and EM school written measures and the AV and EM practical measures.

4. The EW written and practical measures, as well as the majority of all the "A" school practical measures, would be very poorly predicted by the majority of the cluster variables.

Class "C" Schools

1. All "C" school predictor variables, except for the arithmetic reasoning subtest (ART) of the BTB, correlated significantly with the AE/AV "C" school final exam score.

2. The general classification BTB subtest (GCT), the AE/AV "C" school diagnostic computer test, and the NAVPERSRANDCEN "C" school math test had moderately low correlations with the AE/AV "C" school final.

3. The AE/AV diagnostic mathematics and diagnostic electronics tests had moderately high correlations with the AE/AV "C" school final score.

4. The electronics predictor cluster accounted for more of the variance of the AE/AV "C" school exam than did the other predictor clusters.

Conclusions

1. The NAVPERSRANDCEN-developed mathematics tests and the ASVAB MK and EI subtests were the strongest predictors of the criterion variables investigated in these studies.

2. The AR ASVAB subtest appears to be of limited value in the schools.

Recommendations

1. A job analysis of electronics maintenance technicians should be conducted.

2. If electronics courses are to remain unchanged as to content, mathematics training should be redistributed within the courses as suggested in this report.

3. Existing mathematics training should be enhanced to increase its efficiency and effectiveness.

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INTRODUCTION

Problem

The sophistication of military equipment is increasing while training budgets remain constrained. Thus, to assure cost-effective training, those skills and knowledges essential for successful job performance in the fleet, as well as the subordinate skills and knowleges that enable the trainee to master essential skills, must be identified. Conversely, those skills and knowledges not required for successful performance must be identified and removed from course objectives.

Background

Navy recruits are assigned to ratings and corresponding Class "A" schools based on scores obtained in the Armed Services Vocational Aptitude Battery (ASVAB), which measures aptitude in a number of areas. Over 23,000 of the approximately 60,000 recruits who enter Navy Class "A" schools every year are trained in electronics maintenance. Before these recruits enter "A" school, however, they must successfully undergo initial training on the fundamentals of electronic theory at one of the Basic Electricity and Electronics (BE/E) preparatory schools. After completing the BE/E and follow-on Class "A" school courses, most students are sent to the fleet. Some then return for more specialized training in electronics equipment at Class "C" schools. There are also a small number of students at the "C" schools who are direct input from the Class "A" schools.

Although preliminary instruction for the electronics schools is more advanced than in most areas of Navy technical training, electronics instructors frequently report that many students are not prepared to begin school curricula. They cite mathematical skills as a primary deficiency among students and view this inadequacy as contributing significantly to unsatisfactory performance in electronics.

To address this problem, the Navy Personnel Research and Development Center (NAVPERSRANDCEN) conducted a project designed to identify mathematical requirements relevant to electronics training. The purpose of the first task conducted under this project was to identify the mathematics skills necessary for successful performance in the Navy's electronics "A" schools (Sachar & Baker, 1981). After several electronics textbooks had been reviewed, 70 candidate skills were identified and grouped into 14 topic areas. Next, a survey form that included problems for each of the 70 skills identified was developed and administered to instructors in 14 electronics "A" schools. Respondents were asked to indicate the level of importance of the skill to the course and the level of instruction provided. Survey results were used to develop tests, which were then administered to entering and graduating "A" school students to assess their proficiency in skills rated as affecting performance (Berger, Marr, Cremer, & Berger, 1981). Other reports issued under this project identified the skills needed to perform successfully in Navy BE/E schools, in Class "C" schools, and in the job environment (Baker, 1981a, b, c).

Purpose

The purposes of this effort were to examine the relationship between mathematics ability and electronics school performance and, based on results obtained and those described in previous reports on this project, specify the mathematics skills required to complete Navy electronics training successfully and function adequately in electronics maintenance in the fleet.

APPROACH

Separate analyses were conducted for the BE/E schools, the Class "A" schools, and one Class "C" school.

BASIC ELECTRICITY AND ELECTRONICS SCHOOLS

Participants

Participants were 160 BE/E graduating students representing all four BE/E school locations (Orlando, Florida; Great Lakes, Illinois; San Diego, California; and Memphis, Tennessee) who had completed Modules 1 through 14 of the BE/E course. Performance data for 377 BE/E graduates had been obtained for a previous research effort (Baker, 1981a). However, 217 graduates were excluded from the present analyses either because of missing data or because they had not completed through Module 14 of the BE/E course.

Measures

The predictor variables consisted of scores obtained on six ASVAB subtests and a NAVPERSRANDCEN mathematics test that had been developed for BE/E students (Baker, 1981a). The criterion variables consisted of the BE/E final test score and time in course. Variables are described in Table 1.

Analyses

The means, standard deviations, and intercorrelations of the nine variables were computed. Additionally, scatterplots were produced of the seven predictor variables against the criterion variables. These statistics provided a description of the variables and assurance that the assumptions of more complex analyses were not violated. A cluster analysis was then performed to determine empirically how the seven predictor variables grouped together.[1] This was necessary because it would have been difficult to grasp the importance of a single predictor variable when it was correlated empirically and interrelated theoretically with the others. If the larger groupings provide intuitive meaning to the user, the value of the study results should be enhanced. The final decision on how the variables were grouped was not a straightforward objective process but, rather, a combination of analytical methods and judgment. Finally, the squared multiple correlations of the four predictor clusters with each of the two criterion variables were computed.

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[1]The BMDP P1M cluster program (Dixon & Brown, 1979) was used with the tests' correlation matrix as input and average similarity as the criterion for clustering the tests.

Table 1

BE/E School Predictor and Criterion Variables

Variable	Description
Predictor variables:[a]	
1. Word knowledge (WK) test score	A 30-item, 4-option, multiple-choice test measuring vocabulary.
2. General science (GS) test score	A 20-item, 4-option, multiple-choice test measuring knowledge in the physical and biological sciences.
3. Electronics information (EI) test score	A 30-item, 4-option, multiple-choice test requiring knowledge of electrical and electronic components, principles, and symbols.
4. Mechanical comprehension (MC) test score	A 20-item, 3-option, multiple-choice test measuring understanding of mechanical principles illustrated in drawings.
5. Arithmetic reasoning (AR) test score	A 20-item, 4-option, multiple-choice arithmetic test requiring examinees to solve word problems.
6. Mathematics knowledge (MK) test score[a]	A 20-item, 4-option, multiple-choice test requiring knowledge of algebra, geometry, fractions, decimals, and exponents.
7. NAVPERSRANDCEN BE/E mathematics test score	A 100-item, 4-option, multiple-choice test requiring knowledge of decimals, exponents, fractions, unit conversions, scientific notation, algebra, geometry, and trigonometry (Baker, 1981a).
Criterion variables:	
8. BE/E final test score	A 76-item, 4-option, multiple-choice test measuring knowledge taught in modules 1-14 of BE/E. Topics include reading circuit schematics; computing voltage, current, and resistance; and using a multimeter.
9. BE/E time in course	The total number of hours the student spent in completing the self-paced BE/E course.

[a]Predictors 1-6 are scores from ASVAB subtests (from ASVAB Forms 5, 6, or 7).

Results

Correlations

The means and standard deviations of the criterion and predictor variables are presented in Table 2. Scatterplots produced did not reveal noticeable curvilinearity in the relationship between criterion variables and the seven predictor variables. There was, however, one score of 14 on the BE/E final that was much lower than the next lowest score of 43 and the mean of 80. In addition, there were two outliers in the time in course scores, 783 and 999, which were much higher than the next lowest score of 538 and the mean of 236. For the present analyses, they were not discarded, although trimming of the scores (as discussed by Tukey (1977)) might be advisable for future analyses.

Table 2

Means and Standard Deviations for BE/E School Predictor and Criterion Variables

Variable[a]	Mean	Standard Deviation
1. WK test score[b]	58.9	6.6
2. GS test score[b]	60.1	6.4
3. EI test score[b]	60.1	6.2
4. MC test score[b]	56.7	6.4
5. AR test score[b]	59.3	5.9
6. MK test score[b]	61.1	4.8
7. NAVPERSRANDCEN BE/E mathematics test score[c]	73.6	13.0
8. BE/E final test score[d]	79.8	11.3
9. BE/E time in course[e]	236.2	115.9

[a]Variables 1-7 are predictor variables; and 8-9, criterion variables.

[b]Navy standard scores (NSS) having a mean of about 50 and a standard deviation of 10 for an unrestricted recruit population.

[c]Raw scores for a test with 100 items.

[d]Percentage score.

[e]Hours spent in a self-paced course.

Intercorrelations computed between the nine BE/E variables are presented in Table 3. As shown, correlations obtained between the BE/E final test score and all predictors, except for the WK test score, were statistically significant. Most of these correlations were within a moderate range, with the best predictor of BE/E course performance being the NAVPERSRANDCEN constructed mathematics test. Test scores for EI, MC, and MK tests were all better predictors of BE/E course performance than was the AR test score.

The MK test score was the only predictor that correlated significantly with BE/E time in course, and this correlation was quite low.

Table 3

Intercorrelations of BE/E School Predictor and Criterion Variables

Variable[a]	1	2	3	4	5	6	7	8	9
1. WK test score	1.00	.54**	.29**	.26**	.31**	.23*	.32**	.08	.07
2. GS test score	.29	1.00	.45**	.43**	.19*	.13	.32**	.26*	-.05
3. EI test score	.08	.20	1.00	.45**	.22*	.09	.33**	.35**	-.13
4. MC test score	.07	.18	.20	1.00	.33**	.18*	.32**	.34**	-.08
5. AR test score	.10	.04	.05	.11	1.00	.38**	.35**	.23*	-.05
6. MK test score	.05	.02	.01	.03	.14	1.00	.54**	.30**	-.15*
7. NAVPERSRAND-CEN BE/E mathematics test score	.10	.10	.11	.10	.12	.29	1.00	.39**	-.14
8. BE/E final test score	.01	.07	.12	.12	.05	.09	.15	1.00	-.27*
9. BE/E time in course	.00	.00	.02	.01	.00	.02	.02	.07	1.00

Note. The entries above the principal diagonal of the correlation matrix are zero-order correlations, while those below the diagonal are squared zero-order correlations.

[a]Variables 1-7 are predictor variables; and 8-9, criterion variables.

*$p < .05$.

**$p < .01$.

Cluster Analysis

Based on a cluster analysis and knowledge of the measures, four clusters of predictor variables were formed. Table 4 presents the four clusters, the measures included in each, and a cluster name. The clusters are numbered to allow easy identification of the variables included in the squared multiple correlations also presented in Table 4. These correlations indicate that the mathematics and electronics clusters each contribute approximately 16 percent of the variance in the BE/E final exam score, while the verbal and arithmetic reasoning clusters contributed only 7 and 5 percent respectively. Combining the mathematics and electronics clusters ($R^2_{y.24}$) increased accountable variance of the written measure; recombining these two clusters with the verbal cluster ($R^2_{y.124}$) again increased the amount of variance in the BE/E final accounted for by the predictor variance. However, the addition of the arithmetic reasoning cluster to the regression equations ($R^2_{y.1234}$) did not significantly increase predictability of BE/E exam performance. None of the predictor variables accounted for a significant portion of the variance of BE/E time-in-course.

Table 4

BE/E School Variable Clusters and Squared Multiple Correlations

Test Clusters		
Cluster No.	Tests	Cluster
1	WK and GS	Verbal
2	EI and MC	Electronics
3	AR	Arithmetic reasoning
4	MK and NAVPERSRANDCEN BE/E mathematics	Mathematics

Squared Multiple Correlations with BE/E Final Test Score			
$R^2_{y.1} = .071^{**}$	$R^2_{y.2} = .163^{**}$	$R^2_{y.3} = .047^{**}$	$R^2_{y.4} = .166^{**}$
$R^2_{y.12} = .174^{**}$	$R^2_{y.13} = .109^{**}$	$R^2_{y.14} = .208^{**}$	$R^2_{y.23} = .172^{**}$
$R^2_{y.24} = .245^{**}$	$R^2_{y.34} = .169^{**}$		
$R^2_{y.123} = .188^{**}$	$R^2_{y.124} = .268^{**}$	$R^2_{y.134} = .245^{**}$	$R^2_{y.234} = .214^{**}$
$R^2_{y.1234} = .268^{**}$			

Squared Multiple Correlations with BE/E Time in course			
$R^2_{y.1} = .015$	$R^2_{y.2} = .018$	$R^2_{y.3} = .003$	$R^2_{y.4} = .028$
$R^2_{y.12} = .033$	$R^2_{y.13} = .021$	$R^2_{y.14} = .052$	$R^2_{y.23} = .018$
$R^2_{y.24} = .038$	$R^2_{y.34} = .028$		
$R^2_{y.123} = .036$	$R^2_{y.124} = .064$	$R^2_{y.134} = .051$	$R^2_{y.234} = .039$
$R^2_{y.1234} = .064$			

* F ratio $p < .05$.

** F ratio $p < .01$.

CLASS "A" SCHOOLS

Participants

Participants were 753 graduating students from the 10 electronics "A" schools listed in Table 5. Performance data for 1,238 "A" school graduates had been obtained for a previous research effort (Berger et al., 1981). For the present analysis, 485 of these subjects were excluded because of missing data.

Table 5

"A" School Sample Sizes

School	Number of Students
Aviation Electrician's Mate (AE)	101
Avionics Technician (AV)	113
Construction Electrician (CE), Gulfport[a]	20
Construction Electrician (CE), Port Hueneme[a]	29
Data Systems Technician (DS)	63
Electrician's Mate (EM)	119
Electronics Technician (ET)	118
Electronics Warfare Technician (EW)	53
Fire Control Technician (FT)	30
Gunner's Mate (GM)	107
Total	753

[a]The two locations of the CE school were analyzed separately to determine if differences would exist between sites on any of the variables under consideration.

Measures

The predictor variables consisted of scores obtained on six ASVAB subtests and a NAVPERSRANDCEN mathematics test that had been developed for "A" school students (Berger et al., 1981). The criterion variables were the "A" school written test score and practical score. These variables are described in Table 6.

Analysis

The mean, standard deviations, and intercorrelations of the nine variables were computed for each "A" school. A cluster analysis for each "A" school was then performed to determine empirically how the seven predictor variables grouped together. The clustering procedure was essentially the same as that employed for the analysis of the BE/E school data. Finally, the squared multiple correlations of the four predictor clusters with each of the two criterion variables for each school were computed.

Results

Correlations

Table 7 presents the means and standard deviations of the criterion and predictor variables for each "A" school. The small standard deviations and high means on the

Table 6

"A" School Predictor and Criterion Variables

Variable	Description
Predictor Variables:[a]	
1. WK test score	A 30-item, 4-option, multiple-choice test measuring vocabulary.
2. GS test score	A 20-item, 4-option, multiple-choice test measuring knowledge in the physical and biological sciences.
3. EI test score	A 30-item, 4-option, multiple-choice test requiring knowledge of electrical and electronic components, principles, and symbols.
4. MC test score	A 20-item, 3-option, multiple-choice test measuring understanding of mechanical principles illustrated in drawings.
5. AR test score	A 20-item, 4-option, multiple-choice arithmetic test requiring examinees to solve word problems.
6. MK test score	A 20-item, 4-option, multiple-choice test requiring knowledge of algebra, geometry, fractions, decimals, and exponents.
7. NAVPERSRANDCEN "A" School mathematics test score	Varied (by school)-item, 4-option, multiple-choice tests developed specifically to access the mathematical requirements of each Navy "A" school in the electronics training pipeline (Berger et al., 1981).
Criterion Variables:	
8. "A" school written test score	Defined as follows for the various schools: • AE school--85-item final exam. • AV school--50-item comprehensive final exam. • CE school, Gulfport--95 items, the average of written exams on power and wiring. • CE school, Port Hueneme--100-item comprehensive final exam on power, wiring, and communications. • DS school--the average of all sectional exams. • EM school--60-item comprehensive final. • ET school--the average of 8 sectional exams. • EW school--50-item final exam. • FT school--65-item comprehensive final exam. • GM school--the average of weekly exams.
9. "A" school practical score	Defined as follows for the various schools: • AE school--the average of seven practical exams. • AV school--the total number of errors across all practical exams given during the course. • CE school, Gulfport--score on a single practical requiring a two-man team to put up power poles and install wiring thereon. • CE school, Port Hueneme--the average of five practical exams on power, wiring, communications, pole climbing, and cubicle. • DS school--the average of all laboratory exams given during the course. • EM school--the sum of all practical scores obtained during the course. • ET school--the average of all laboratory scores obtained during the course. • EW school--an individual performance score on a 10-point scale of competency. • FT school--the sum of two practical exams, one dealing with oscilloscope and transistor theory and the other with gyro and synchro theory. • GM school--the average of all practical exams given during the course.

[a]Predictors 1-6 are scores from ASVAB subtests (from ASVAB forms 5, 6, and 7).

Table 7

Means and Standard Deviations of "A" School Predictor and Criterion Variables

Variable[a]		"A" School AE (N = 101)	AV (N = 113)	CE Gulfport (N = 20)	CE Port Hueneme (N = 29)	DS (N = 63)	EM (N = 119)	ET (N = 118)	EW (N = 53)	FT (N = 30)	GM (N = 107)
1. WK test score[b]	$\bar{X}$	55.5	58.8	54.1	54.9	59.5	54.7	59.9	59.4	58.4	54.2
	SD	7.4	5.9	8.2	6.8	5.8	8.2	5.7	5.3	7.1	6.2
2. GS test score[b]	$\bar{X}$	55.9	60.7	54.8	55.6	60.5	56.1	61.4	60.7	62.0	55.9
	SD	7.2	6.3	6.4	6.3	5.6	7.9	6.6	5.4	4.9	6.9
3. EI test score[b]	$\bar{X}$	56.8	60.2	55.2	57.9	61.4	55.7	61.2	61.2	61.6	57.4
	SD	7.3	5.6	6.5	8.5	5.8	8.1	5.6	5.6	4.3	4.9
4. MC test score[b]	$\bar{X}$	53.8	57.6	53.9	52.3	56.9	53.7	58.1	57.9	60.5	53.6
	SD	8.4	6.2	7.7	8.5	5.9	7.1	6.9	6.8	6.0	7.4
5. AR test score[b]	$\bar{X}$	55.6	58.5	55.2	55.1	61.2	56.6	62.1	59.4	60.5	53.9
	SD	6.6	5.4	5.2	6.0	5.6	6.8	5.0	5.0	6.5	5.5
6. MK test score[b]	$\bar{X}$	57.4	60.5	56.4	57.2	61.2	59.9	62.8	60.0	60.5	55.3
	SD	6.6	6.1	4.1	5.0	4.3	4.9	4.2	4.9	5.3	5.5
7. NAVPERSRAND-CEN "A" school mathematics test score[c]	$\bar{X}$	41.2	40.3	31.4	42.8	39.6	37.6	55.2	47.3	36.7	22.9
	SD	15.5	13.0	15.3	21.2	13.7	20.6	14.8	15.4	14.1	10.3
	T	99.0	78.0	101.0	101.0	83.0	95.0	88.0	86.0	92.0	91.0
8. "A" school written score[c]	$\bar{X}$	73.3	43.3	88.6	86.9	79.8	45.6	79.7	75.5	40.4	77.5
	SD	8.2	2.6	5.6	4.7	18.9	6.6	7.4	10.8	8.1	5.0
	T	100.0	50.0	99.0	99.0	100.0	60.0	100.0	100.0	65.0	99.0
9. "A" school practical score[c]	$\bar{X}$	86.2	1.7	92.9	88.7	83.2	38.8	89.2	79.3	105.3	90.1
	SD	4.3	1.3	1.5	2.8	25.1	1.1	4.1	9.8	6.6	8.0
	T	99.0	6.0	99.0	99.0	100.0	40.0	100.0	100.0	110.0	99.0

[a] Variables 1-7 are predictor variables; and 8-9, criterion variables.
[b] Navy standard scores (NSS) $\bar{X}$ = 50, SD = 10 for an unrestricted recruit population.
[c] T = Total possible score.

practical exam suggests that these scores cannot correlate highly with any predictors; there is a "ceiling" effect for the practical exam scores. The intercorrelations of the nine variables for each "A" school are presented in Table 8 and discussed below.

1. AE school. As shown, the AE school written performance measure correlated significantly with only two predictor variables--the MK and NAVPERSRANDCEN "A" school mathematics scores--and these correlations were moderately low. There were significant but moderately low correlations between the AE school practical measure and the WK and GS test scores and a significant and moderate correlation between the practical measure and the NAVPERSRANDCEN mathematics test score.

2. AV school. The EI, MC, MK, and NAVPERSRANDCEN mathematics test scores produced moderately low significant correlations with the AV school written performance measure. The EI, MC, and MK test scores also correlated at a moderately low level with the AV school practical exam.

3. CE school, Gulfport.[2] The correlations of the CE school written measure were significant for only the EI and MC test scores; however, these correlations were moderately high and high respectively. The GS and MC test scores correlated moderately high with the CE school practical measure.

4. CE school, Port Hueneme. The correlations of the CE school written measure were significant and moderately high for the WK, MC, AR, and NAVPERSRANDCEN mathematics test scores, with the latter being the most strongly correlated. The CE school practical measure correlated significantly with only the MC test score.

5. DS school. There were no significant correlations between the DS school written and practical measures and any of the seven predictors.

6. EM school. All predictors, except for the AR test scores, correlated significantly with the EM school written measure at a moderately low level. The strongest predictors were the NAVPERSRANDCEN mathematics and EI test scores; the latter was the only predictor correlating significantly with the EM school practical exam.

7. ET school. All seven predictors correlated with the ET "A" school written measure. However, only the correlations for the MK and NAVPERSRNADCEN mathematics test scores were moderately high; the remainder were moderately low. The MK test score was only predictor to correlate significantly with the ET "A" school practical measure.

8. EW school. The NAVPERSRANDCEN mathematics test score was the only predictor that correlated significantly with the EW school written measure, and this

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[2]Data from two locations of the CE "A" schools were analyzed independently to determine whether correlations would be somewhat consistent across locales. As can be seen in Table 8, the CE school, Gulfport written measure correlated most highly with the MC test score and not significantly with any of the mathematics measures, while the CE school, Port Hueneme written test correlated with the NAVPERSRANDCEN mathematics and AR test scores as well as the MC test scores. Both school practical measures correlated with the MC test scores, and the CE school, Gulfport practical also correlated with the GS test score. These differences between locales may be due to aptitude differences and/or curriculum and evaluation variations.

Table 8

Intercorrelations of "A" School Predictor and Criterion Variables

	Variable	1	2	3	4	5	6	7	8	9
					AE School					
1.	WK test score	1.000	.451**	.190	.289*	.374**	.351**	.111	-.045	.209*
2.	GS test score	.203*	1.000	.383**	.612**	.423**	.603**	.087	-.038	.213*
3.	EI test score	.036	.147	1.000	.507**	.314**	.460**	-.055	.075	.143
4.	MC test score	.084	.375	.257	1.000	.358**	.482**	.016	.190	.187
5.	AR test score	.140	.179	.099	.128	1.000	.548**	.147	.040	-.018
6.	MK test score	.123	.364	.212	.232	.300	1.000	.289*	.211*	.165
7.	NAVPERSRANDCEN "A" school mathematics test score	.012	.008	.003	.000	.022	.084	1.000	.278*	.377**
8.	"A" school written score	.002	.001	.006	.036	.002	.045	.077	1.000	.291*
9.	"A" school practical score	.044	.045	.020	.035	.000	.027	.142	.085	1.000
					AV School					
1.	WK test score	1.000	.496**	.124	.063	.120	.229*	.074	.172	.040
2.	GS test score	.246	1.000	.484**	.274*	.069	.313**	.059	.171	-.090
3.	EI test score	.015	.234	1.000	.343**	-.067	.300**	-.009	.286*	-.312**
4.	MC test score	.004	.075	.118	1.000	.136	.153	.071	.347**	-.264*
5.	AR test score	.014	.005	.004	.018	1.000	.294*	.305**	.014	.043
6.	MK test score	.052	.098	.090	.023	.086	1.000	.482**	.237*	-.309**
7.	NAVPERSRANDCEN "A" school mathematics test score	.005	.003	.000	.005	.093	.232	1.000	.244*	-.121
8.	"A" school written score	.030	.029	.082	.120	.000	.056	.050	1.000	-.290*
9.	"A" school practical score	.002	.008	.097	.070	.002	.095	.015	.084	1.000
					CE School, Gulfport					
1.	WK test score	1.000	.543*	.288	.480*	.355	.164	.138	.357	.218
2.	GS test score	.295	1.000	.479*	.687**	.485*	.525*	.404	.417	.591*
3.	EI test score	.083	.229	1.000	.790**	.502*	.270	.133	.539*	.328
4.	MC test score	.230	.472	.624	1.000	.598*	.201	.332	.722**	.514*
5.	AR test score	.126	.235	.252	.358	1.000	.496*	.570*	.395	.224
6.	MK test score	.027	.276	.073	.040	.246	1.000	.536*	.091	.288
7.	NAVPERSRANDCEN "A" school mathematics test score	.019	.163	.018	.110	.325	.287	1.000	.430	.395
8.	"A" school written score	.127	.174	.291	.521	.156	.008	.185	1.000	.541*
9.	"A" school practical score	.048	.350	.108	.264	.050	.083	.156	.293	1.000
					CE School, Port Hueneme					
1.	WK test score	1.000	.739**	.382*	.511**	.475*	.321	.226	.456*	.033
2.	GS test score	.546	1.000	.439*	.404*	.458*	.183	.270	.341	.130
3.	EI test score	.146	.193	1.000	.568**	.443*	.405*	.146	.067	.258
4.	MC test score	.261	.163	.323	1.000	.390*	.461*	.463*	.427*	.369*
5.	AR test score	.225	.210	.196	.152	1.000	.389*	.466*	.494*	.233
6.	MK test score	.103	.033	.164	.213	.151	1.000	.602**	.347	.358

Note. The entries above the principal diagonal of the correlation matrix are zero-order correlations, while those below the diagonal are squared zero-order correlations.

*$p < .05$.

**$p < .01$.

Table 8 (Continued)

Variable	1	2	3	4	5	6	7	8	9
CE School, Port Hueneme (Continued)									
7. NAVPERSRANDCEN "A" school mathematics test score	.051	.073	.021	.214	.217	.362	1.000	.572**	.303
8. "A" school written score	.208	.116	.004	.182	.244	.120	.327	1.000	.309
9. "A" school practical score	.001	.017	.067	.136	.054	.128	.092	.095	1.000
DS School									
1. WK test score	1.000	.476**	.290*	.245	.110	.089	.139	-.001	-.196
2. GS test score	.227	1.000	.402**	.137	.074	.335*	.273*	-.036	-.062
3. EI test score	.084	.162	1.000	.607**	.026	.183	.125	.088	.054
4. MC test score	.060	.019	.368	1.000	.150	.101	.060	-.190	-.136
5. AR test score	.012	.005	.001	.023	1.000	.140	.363*	-.089	-.185
6. MK test score	.008	.112	.033	.010	.020	1.000	.430**	-.119	-.076
7. NAVPERSRANDCEN "A" school mathematics test score	.019	.075	.016	.004	.0132	.185	1.000	-.140	-.192
8. "A" school written score	.000	.001	.008	.036	.008	.014	.020	1.000	.659**
9. "A" school practical score	.038	.004	.003	.018	.034	.006	.037	.434	1.000
EM School									
1. WK test score	1.000	.646**	.454**	.451**	.573**	.244*	.371**	.188*	.115
2. GS test score	.417	1.000	.551**	.621**	.492**	.281*	.399**	.210*	.080
3. EI test score	.206	.304	1.000	.539**	.269*	.322**	.451**	.424**	.257*
4. MC test score	.203	.386	.291	1.000	.477**	.310**	.393**	.285*	.148
5. AR test score	.328	.242	.072	.228	1.000	.591**	.573**	.137	.113
6. MK test score	.060	.079	.104	.096	.349	1.000	.697**	.310**	.097
7. NAVPERSRANDCEN "A" school mathematics test score	.138	.159	.203	.154	.328	.486	1.000	.392**	.080
8. "A" school written score	.035	.044	.180	.081	.019	.096	.154	1.000	.116
9. "A" school practical score	.013	.006	.066	.022	.013	.009	.006	.013	1.000
ET School									
1. WK test score	1.000	.429**	.139	.307**	.225*	.120	.316**	.218*	.036
2. GS test score	.184	1.000	.105	.377**	.082	.056	.233*	.217*	-.044
3. EI test score	.019	.011	1.000	.409**	.125	.008	.145	.295**	-.020
4. MC test score	.094	.142	.167	1.000	.203*	.130	.319**	.326**	.142
5. AR test score	.050	.007	.016	.041	1.000	.474**	.442**	.231*	.121
6. MK test score	.014	.003	.000	.017	.225	1.000	.555*	.354**	.236*
7. NAVPERSRANDCEN "A" school mathematics test score	.100	.054	.021	.102	.170	.308	1.000	.532**	.157
8. "A" school written score	.048	.047	.087	.106	.053	.125	.283	1.000	.351**
9. "A" school practical score	.001	.002	.000	.020	.015	.056	.025	.123	1.000

Note: The entries above the principal diagonal of the correlation matrix are zero-order correlations, while those below the diagonal are squared zero-order correlations.

*$p < .05$.

**$p < .01$.

Table 8 (Continued)

Variable	1	2	3	4	5	6	7	8	9
EW School									
1. WK test score	1.000	.284*	.068	.170	.177	.147	.158	.004	-.044
2. GS test score	.081	1.000	.286*	.224	.057	-.044	-.103	.060	-.132
3. EI test score	.005	.082	1.000	.303*	-.238	-.181	-.090	.132	-.127
4. MC test score	.029	.050	.092	1.000	.268	.061	.198	.218	.037
5. AR test score	.031	.003	.057	.072	1.000	.603**	.511**	.141	.086
6. MK test score	.022	.002	.033	.004	.364	1.000	.663**	.181	.106
7. NAVPERSRANDCEN "A" school mathematics test score	.025	.011	.008	.039	.261	.440	1.000	.274*	.175
8. "A" school written score	.000	.004	.017	.048	.020	.033	.075	1.000	.187
9. "A" school practical score	.002	.017	.016	.001	.007	.011	.031	.035	1.000
FT School									
1. WK test score	1.000	.415*	.150	.390*	.315	.616	.359	.514**	.328
2. GS test score	.172	1.000	.472**	.415*	-.125	.387*	.124	.181	.096
3. EI test score	.023	.223	1.000	.358	-.123	.341	.145	.341	.103
4. MC test score	.152	.172	.128	1.000	.517**	.516**	.321	.207	.187
5. AR test score	.099	.016	.015	.267	1.000	.508**	.480**	.285	.206
6. MK test score	.379	.150	.116	.266	.258	1.000	.718**	.698**	.351
7. NAVPERSRANDCEN "A" school mathematics test score	.129	.015	.021	.103	.230	.516	1.000	.695**	.311
8. "A" school written score	.264	.033	.116	.043	.081	.487	.483	1.000	.399*
9. "A" school practical score	.108	.009	.011	.035	.042	.123	.097	.159	1.000
GM School									
1. WK test score	1.000	.470**	.223*	.181	.178	-.047	.038	.208*	.105
2. GS test score	.221	1.000	.176	.320**	.120	-.056	.006	.142	.019
3. EI test score	.050	.031	1.000	.311**	.092	.045	.100	.177	.055
4. MC test score	.033	.102	.097	1.000	.162	-.089	-.106	.180	.198*
5. AR test score	.032	.014	.008	.026	1.000	.391**	.473**	.164	.137
6. MK test score	.002	.003	.002	.008	.153	1.000	.490**	.122	.182
7. NAVPERSRANDCEN "A" school mathematics test score	.001	.000	.010	.011	.224	.240	1.000	.237*	.265**
8. "A" school written score	.043	.020	.031	.032	.027	.015	.056	1.000	.556**
9. "A" school practical score	.011	.000	.003	.039	.019	.033	.070	.309	1.000

Note. The entries above the principal diagonal of the correlation matrix are zero-order correlations, while those below the diagonal are squared zero-order correlations.

*p < .05.

**p < .01.

correlation was moderately low. None of these seven predictor measures correlated with the EW school practical exam.

9. FT school. The FT school written measure had a significant correlation with the WK, MK, and NAVPERSRANDCEN mathematics test scores. These correlations were moderately high for the WK test score and high for the two mathematics predictor variables. The FT school practical did not correlate significantly with any of the predictor measures.

10. GM school. Only the NAVPERSRANDCEN mathematics test score had a significant correlation with both the GM school written and practical exams, and these correlations were low. The WK test score had significant but low correlation with the GM school written measure, and the MK test score had a significant but low correlation with the GM school practical measure.

Cluster Analysis

Based on the cluster analysis and knowledge of these tests, four clusters of predictor variables were formed. Table 9 presents the four clusters, the measures included in each and a cluster name. The clusters are numbered to allow easy identification of the measures included in the squared multiple correlations also presented in Table 9.

The clustering of measures and the subsequent multiple regression analysis produced consistent results across the majority of Class "A" schools and were similar to results obtained in the BE/E school. In five of the ten "A" schools (AE, CE Port Hueneme, ET, FT, and GM), the mathematics cluster accounted for the most attributable variance in the written school measures. In three of these schools (AE, FT, and GM), it also represented most of the accountable variance with the practical measures. The electronics cluster accounted for most of the attributable variance in the AV, CE Gulfport, DS, and EM school written measures and in the AV and EM practicals. The EW written and practical, as well as the majority of the "A" school practical measures, would be very poorly predicted by the majority of the cluster variables. Combining the electronics and mathematics clusters ($R^2_{y.24}$) increased accountable variance of the "A" school written measures; recombining these two clusters with the verbal cluster ($R^2_{y.124}$) again increased the amount of variance in the written tests that could be accounted for by predictor variance. However, the addition of the arithmetic reasoning cluster to the regression equations ($R^2_{y.1234}$) did not appreciably increase predictability in the majority of "A" schools.

Table 9

"A" School Variable Clusters and Squared Multiple Correlations

Test Clusters		
Cluster No.	Tests	Cluster
1	WK and GS	Verbal
2	EI and MC	Electronics
3	AR	Arithmetic reasoning
4	MK and NAVPERSRANDCEN "A" school mathematics	Mathematics

Squared Multiple Correlations with "A" School Written (W) and Practical (P) scores

	AE		AV		CE Gulfport		CE Port Hueneme		DS		EM		ET		EW		FT		GM	
	W	P	W	P	W	P	W	P	W	P	W	P	W	P	W	P	W	P	W	P
$R^2_{y.1}$	.061*	.002	.039	.017	.198	.364*	.208*	.025	.001	.039	.048	.013	.066*	.005	.003	.017	.265*	.109	.045	.012
$R^2_{y.2}$	.038	.036	.151**	.125**	.523**	.280	.226*	.139	.101*	.047	.184**	.066*	.137*	.027	.052	.022	.124	.036	.048	.039
$R^2_{y.3}$	.000	.001	.000	.001	.155	.050	.243**	.054	.007	.034	.018	.012	.053*	.014	.019	.007	.080	.042	.026	.018
$R^2_{y.4}$	.145**	.095**	.078*	.096**	.212	.163	.326**	.140	.023	.036	.156**	.009	.288**	.056*	.074	.030	.564**	.130	.056*	.073*
$R^2_{y.12}$	.067	.075	.174**	.135*	.538*	.404	.325*	.189	.120	.091	.189**	.076	.157**	.040	.053	.035	.369*	.120	.073	.052
$R^2_{y.13}$	.084	.007	.039	.019	.239	.367	.309*	.074	.009	.066	.049	.018	.101**	.018	.024	.026	.280*	.119	.061	.027
$R^2_{y.14}$	.190**	.134**	.098*	.112*	.364	.403	.453**	.175	.024	.071	.160**	.018	.299**	.061	.087	.045	.591**	.157	.099*	.084
$R^2_{y.23}$	.048	.037	.151**	.127**	.525**	.290	.417**	.146	.103	.071	.184**	.068*	.163**	.037	.065	.023	.242	.060	.065	.05[illegible]
$R^2_{.24}$	.186**	.114*	.204**	.172**	.599**	.339	.381*	.184	.113	.089	.233**	.070	.347**	.074	.115	.045	.625**	.130	.107*	.128**
$R^2_{y.34}$	.161**	.103*	.085*	.115**	.268	.164	.393**	.145	.025	.052	.173**	.014	.288**	.056	.074	.030	.583**	.130	.059	.073*
$R^2_{y.123}$	.096	.076	.175**	.136**	.539*	.421	.448*	.209	.121	.108	.189**	.080	.178**	.049	.068	.037	.419*	.127	.085	.061
$R^2_{y.124}$	.212**	.195**	.223**	.196**	.609*	.422	.475*	.250	.141	.123	.242**	.080	.351**	.086	.122	.056	.675**	.159	.130*	.141*
$R^2_{y.134}$	.220**	.137*	.107*	.128*	.378	.421	.474**	.184	.026	.083	.187**	.020	.299**	.061	.087	.045	.624**	.158	.099	.084
$R^2_{y.234}$	.210**	.125*	.212**	.189**	.614*	.419	.471**	.185	.133	.096	.256**	.074	.349**	.074	.115	.046	.625**	.130	.107*	.132*
$R^2_{y.1234}$	.247**	.200**	.233**	.210**	.632*	.472	.516*	.260	.141	.128	.259**	.087	.353**	.086	.122	.056	.676**	.159	.130*	.147*

*F ratio $p < .05$.

**F ratio $p < .01$.

CLASS "C" SCHOOL (AVIATION ELECTRICIAN'S MATE/AVIONICS TECHNICIAN (AE/AV))

Participants

Participants were 38 graduating students from the AE/AV "C" school located in Memphis, Tennessee. Performance data for 50 such students had been obtained for a previous research effort (Baker, 1981b). In the present analysis, 12 subjects were excluded because of missing data.

Measures

The predictor variables included scores obtained in (1) two subjects of tne Basic Test Battery (BTB), the forerunner of the ASVAB, (2) three sections of the AE/AV "C" school entrance test, and (3) a NAVPERSRANDCEN mathematics test developed for AE/AV "C" school students (Baker, 1981b). The AE/AV "C" school final exam score was the criterion variable. The variables are described in Table 10.

Analyses

The means, standard deviations, and intercorrelation of the seven variables were computed. Additionally, scatterplots were produced for each of the six predictor variables against the criterion variable. These statistics provided a description of the variables and assurance that the assumption of more complex analysis were not violated. A cluster analysis was then performed to determine empirically how the six predictor variables grouped together. The clustering procedure was essentially the same as that employed for the analyses of the BE/E and Class "A" school data. Finally, the squared multiple correlations of the four predictor clusters with the criterion variable were computed.

Results

Correlations

Table 11 presents the means and standard deviations of the criterion and predictor variables; and Table 12, the intercorrelations. Scatterplots did not reveal noticeable curvilinearity in the relationship between the AV "C" final and the six predictor variables.

All predictor variables, except for the ART test score, correlated significantly with the AE/AV "C" school final exam. The GCT, diagnostic computer, and NAVPERS-RANDCEN mathematics test scores had moderately low correlations with the final test scores, while the diagnostic mathematics and electronics test scores had moderately high correlations with the AE/AV school final.

Cluster Analysis

Based on the desire to separate mathematics knowledge from general aptitude and electronics knowledge and the results of the cluster analysis, it was decided to form four clusters of predictor variables. Table 13 presents the four clusters, the tests included in each, and a cluster name. Although the content of the NAVPERSRANDCEN mathematics and diagnostic mathematics test are similar, the cluster analysis indicates that diagnostic mathematics is more closely associated with diagnostic electronics and computers than is NAVPERSRANDCEN mathematics. To avoid having to collapse electronics and mathematics, it was decided to keep the NAVPERSRANDCEN mathematics and diagnostic mathematics tests separate.

Table 10

AE/AV "C" School Predictor and Criterion Variables

Variable[a]	Description
Predictor Variables:	
1. General classification test (GCT) score	A 35-item, 5-option, multiple-choice test with 2 item types--sentence completion and verbal analogies.
2. Arithmetic reasoning test (ART) score	A 25-item, 5-option, multiple-choice test of arithmetic word problems.
3. Diagnostic mathematics test score	A 17-item section of the 148-item AE/AV "C" school entrance test. Items are 4-option, multiple-choice questions requiring the performance of higher-order mathematical operations.
4. Diagnostic electronics test score	A 72-item section of the 148-item AE/AV "C" school entrance test. Items are 4-option, multiple-choice questions requiring the recognition of electrical relationships and facts, the reading of electrical diagrams, and the performance of operations necessary to calculate such values as voltage, current, and resistance.
5. Diagnostic computer test score	A 21-item section of the 148-item AE/AV "C" school entrance test. Items are 4-option, multiple-choice requiring demonstration of such skills as coverting numbers to binary, solving Boolean algebra problems, and recognizing facts about computers.
6. NAVPERSRANDCEN AE/AV "C" school mathematics test score	A 93-item completion test measuring performance in the 12 topic mathematical areas identified by AE/AV "C" school instructors as being necessary for successful course performance (Baker, 1981b).
Criterion Variable:	
7. AE/AV "C" school final exam score	A 100-item, 4-option, multiple-choice comprehensive course test. Topics measured by the test include mathematics and electronics fundamentals, D-C and A-C series circuits, networks, semiconductors, amplifiers and oscillators, multivibrators, nonlinear magnetics, computers, and electronics troubleshooting.

[a]GCT and ART are subtests of the Basic Test Battery, the forerunner of the ASVAB, which was administered to military recruits through 1976.

Table 11

Means and Standard Deviations of AE/AV "C" School Predictor and Criterion Variables

	Variable[a]	Mean	Standard Deviation
1.	GCT score[b]	58.1	8.5
2.	ART score[b]	55.8	9.8
3.	Diagnostic mathematics test score[b]	45.6	15.2
4.	Diagnostic electronics test score[c]	34.5	15.4
5.	Diagnostic computer test[c]	43.4	12.4
6.	NAVPERSRANDCEN AE/AV "C" school mathematics test score[d]	65.8	12.4
7.	AE/AV "C" school final exam score[d]	70.8	8.7

Note. Sample size is 38.

[a]Variable 1-6 are predictor variables, and 7, the criterion variable.

[b]Navy standard scores (NSS) $\bar{X}$ = 50, SD = 10 for an unrestricted recruit population.

[c]Translated score with a maximum possible of 99 based on a conversion table; for example, 32 or 33 wrong equates to a score of 77. Each test has a separate conversion table.

[d]Raw score, with a possible maximum of 93.

Table 12

Intercorrelation of AE/AV "C" School Predictor and Correlation Variables

Variable	1	2	3	4	5	6	7
1. GCT score	1.00	.56**	.29	.42**	.35*	.27	.35*
2. ART score	.31	1.00	.32*	.45**	.33*	.30	.19
3. Diagnostic mathematics test score	.08	.10	1.00	.64**	.64**	.47**	.52**
4. Diagnostic electronics test score	.18	.20	.41	1.00	.58**	.49**	.61**
5. Diagnostic computer test score	.12	.11	.41	.34	1.00	.48**	.34*
6. NAVPERSRANDCEN AE/AV "C" school mathematics test score	.07	.09	.22	.24	.23	1.00	.35*
7. AE/AV "C" school final exam score	.12	.04	.27	.37	.12	.12	1.00

Note. The entries above the principal diagonal of the correlation matrix are zero-order correlations, while those below the diagonal are squared zero-order correlations.

[a]Variables 1-6 are predictor variables, and 7, the criterion variable.

*$p < .05$.

**$p < .01$.

Table 13

AE/AV "C" School Variable Clusters and Squared Multiple Correlations

Test Clusters		
Cluster No.	Tests	Cluster
1	GCT and ART	General ability
2	Diagnostic electronics and diagnostic computers	Electronics
3	Diagnostic mathematics	Diagnostic mathematics
4	NAVPERSRANDCEN "C" school mathematics	Mathematics

Squared Multiple Correlations			
$R^2_{y.1} = .124$	$R^2_{y.2} = .374^{**}$	$R^2_{y.3} = .271^{**}$	$R^2_{y.4} = .120$
$R^2_{y.12} = .412^{**}$	$R^2_{y.13} = .324$	$R^2_{y.14} = .197$	$R^2_{y.23} = .412^{**}$
$R^2_{y.24} = .378^{**}$	$R^2_{y.34} = .284^{**}$		
$R^2_{y.123} = .454^{**}$	$R^2_{y.124} = .416^{**}$	$R^2_{y.134} = .334^{**}$	$R^2_{y.234} = .413^{**}$
$R^2_{y.1234} = .455^{**}$			

*F ratio $p < .05$.

**F ratio $p < .01$.

The electronics cluster accounted for more of the variance of the AE/AV "C" school exam than did the other predictor clusters. Combining the electronics and diagnostic mathematics clusters increased the variance accountability; a further increase was obtained when the general ability cluster was combined with the electronics and diagnostic mathematics clusters. The addition of the NAVPERSRANDCEN mathematics cluster to the first three would make no appreciable difference in predictability of AE/AV "C" school performance.

DISCUSSION AND CONCLUSIONS

Overall, the NAVPERSRANDCEN mathematics test score was more strongly correlated, more often, with the criterion measures of the schools represented in the three studies than was any of the other predictor variables. This may be attributed to the greater time lapse between the administration of the other predictor measures and the criterion measures. However, given the number of significant correlations of the MK test score with the criterion variables, it appears that the mathematics aptitude/achievement

tests, along with the electronics aptitude measure, are the strongest predictors of the criterion variables investigated in these studies. The AR test score appears to be of limited value in predicting electronics performance in the schools. The clustering of the predictor measures and subsequent multiple regression analyses support these same conclusions.

The moderately low intercorrelations among the variables of interest in the present studies may be because subject groups contain only those individuals who successfully graduated from the schools. If final scores had been available for attrites, and these had been included in the analyses, the resulting correlations may have been higher. A comparison of the ASVAB scores of the attrites with those of the graduating students might provide some additional insight into this issue.

The BE/E school and Class "A" school subjects in the present studies had been tested with ASVAB Forms 5, 6, or 7. However, since the majority of subtests of interest in these studies were unchanged in the 8, 9, 10 ASVAB series, it is doubtful that significant differences would be found by employing data from the new series.

The fact that mathematics ability consistently correlated more highly with electronics performance, as measured by the schools' written measures, may indicate that the relationship of mathematics to electronics as taught in the schools is above and beyond that contributed by overall general aptitude. The lack of relationship between most of the aptitude measures investigated here and the BE/E and "A" school practical exams may merely be a function of the limited variance potential inherent in most practical exams. Usually, these tests are scored as either pass/fail or on the number/percent correct of a very limited number of tasks. If this is contrasted with the variance potential of a 100-item written test, it is not surprising to find lower correlations with the practical. An alternative interpretation may be that ability measures better predict performance related to the prerequisite learning required to perform a skill, rather than actual skill performance. This view is consistent with the findings of previous efforts where instructors indicated mathematics ability was a necessary prerequisite for understanding electronics (Baker 1981a, b; Sachar & Baker, 1980). However, electronics maintenance technicians indicated that, although an understanding of mathematics was useful in the performance of their jobs, actual use of mathematics at the job station was minimal (Baker 1981c).

Based on the aforementioned findings and results of previous research (Baker, 1981a, b, c; Sachar & Baker, 1980; Berger et al., 1981), it appears that the amount of mathematics taught/required in electronics training should neither be increased nor decreased. Rather, it should merely be redistributed and enhanced to increase its efficiency and effectiveness.

The appendix contains a listing, by rating, of the mathematics requirements associated with each school that is part of the training sequence for the rating. The 70 skills listed for each rating form represent those included in Sachar and Baker's (1980) survey, which was administered to instructors at the BE/E and Class "A" and "C" electronics schools to determine the level of importance of each skill to a course and the level of instruction provided in each skill (Baker, 1981a, b; Sachar & Baker, 1980). For each of these skills, the following is indicated:

1. The level of instruction provided, noted by a P, indicating "Prerequisite" (must possess skill on entrance into course); an R, indicating "Reviewed" (some level of skill is assumed, but skill is reviewed in course), or a T, indicating "Taught" (no previous knowledge assumed, taught explicitly as a skill for the course).

2. Whether the skill is used frequently, rarely, or never by fleet personnel. Information on fleet usage of mathematics was obtained from a previous study (Baker, 1981c).

3. Whether there is a problem with the level of instruction provided at each stage of the training sequence. Problems include having a skill that is prerequisite prior to being taught, reviewed prior to being taught, prerequisite prior to being reviewed, or taught more than once.

One method to increase effectiveness of mathematics training is to revise curricula such that they reflect recent advances in instructional technology. NAVPERSRANDCEN has recently created such a mathematics curriculum for the BE/E school. A series of diagnostic tests and individualized curriculum modules covering only those mathematical skills found to be critical to successful BE/E course performance (Baker, 1981a) were developed and integrated with the BE/E curriculum. Based on their performance in a diagnostic test, students are provided with instruction in only those areas of relevant mathematics in which they are deficient. This approach minimizes the amount of training time necessary to be devoted to mathematics remedial training.[3]

From an analysis of survey data (Sachar & Baker, 1980; Baker, 1981a, b, c) and a cursory review of electronics school course outlines, it appears that the mathematics required in each of the schools is necessary to grasp the electronics curriculum. However, based on previous findings (Berger et al., 1981; Baker, 1981a, b), considerably less sophisticated ability is required to pass each of the courses. This may account for the mathematics skill deficiencies, in areas deemed by instructors as critical to successful course performance, of individuals who have successfully graduated from the course. If it is not required that students fully comprehend the subject of electronics (i.e., if 65% comprehension is sufficient), then course materials should be revised such that only that information, at the comprehension level necessary, be included in with a more thorough understanding of relevant course material. Instead of setting a criterion of 65 percent for a 10-week "A" school comprised of relevant and less-relevant materials, it may be possible to set a criterion of 95 percent for a 3-week course covering only relevant or essential material. To determine what should be included in courses, a job analysis should be conducted--not a complex job/task subskill component analysis, such as would be done under the Navy occupational task analysis program, but, rather, a simple analysis of job tasks and their prerequisites.

Currently, there appears to be a questionable relationship between the job performance requirements of fleet personnel and that which is taught in the schools. As part of a previous effort, a survey was administered to approximately 700 fleet personnel in 10 electronics ratings. Each was asked to indicate how useful on-the-job-training was as compared to school training and how often on-the-job-training was received (Baker, 1981c). Of the personnel surveyed, 72 percent indicated that on-the-job-training was more useful than school training; over half responded that they received this training daily. It may be, of course, that the schools concentrate on theory and prerequisite training that are necessary for successful job performance, but are not apparent skills in use at the job station. However, to ensure that the appropriate prerequisites are being taught and that a sufficiently high criterion is established to ensure mastery of requirements, the aforementioned job analysis should be conducted.

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[3]A NAVPERSRANDCEN technical report documenting the design, development, and evaluation of the BE/E mathematics curriculum will be available in FY83.

RECOMMENDATIONS

1. A job analysis of electronics maintenance technicians should be conducted.

2. If electronics courses are to remain unchanged as to content, mathematics training should be redistributed within the courses as suggested in this report.

3. Existing mathematics training should be enhanced to increase its efficiency and effectiveness.

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APPENDIX

MATHEMATICAL REQUIREMENTS ASSOCIATED WITH SCHOOLS INCLUDED IN TRAINING SEQUENCE FOR ELECTRONIC RATINGS

CONTENTS

Table A-1

Mathematical Requirements Associated with Schools
Included in Training Sequence for AE/AV Rating

Topic Area	Skill	Skill Acquisition Level Ratings[a] BE/E School	"A" Schools AE	"A" Schools AV	"C" Schools	Fleet[b] Usage AE	Fleet[b] Usage AV	Problems with[c] Level of Instruction
Arithmetic Operations with Numbers (4)	1	P	P	R	R	Freq.	Freq.	X
	2	P	P	R	R	--	--	X
	3	--	--	--	R	--	--	X
	4	R	P	R	P	--	Freq.	X
Estimations (1)	5	R	P	R	P	--	--	X
Fractions (5)	6	P	R	--	R	--	--	X
	7	P	P	--	R	--	--	X
	8	--	--	--	R	--	--	X
	9	P	--	--	R	--	--	X
	10	R	--	R	R	--	--	X
Units (4)	11	T	P	R	R	--	Freq.	0
	12	T	P	R	R	--	--	0
	13	T	P	R	R	--	--	0
	14	--	--	R	R	--	--	X
Conversions (3)	15	--	--	--	R	--	Freq.	X
	16	T	P	T	R	--	--	X
	17	--	P	R	--	--	--	X
Scientific Notation (4)	18	T	--	R	T	--	Freq.	X
	19	T	--	R	R	--	--	0
	20	T	--	R	R	--	--	0
	21	T	--	R	R	--	--	0
Decibels (1)	22	--	--	--	T	--	--	0
Logarithms (4)	23	--	--	--	T	--	--	0
	24	--	--	--	T	--	--	0
	25	--	--	--	T	--	--	0
	26	--	--	--	T	--	--	0
Linear Equations (2)	27	T	P	R	R	--	--	0
	28	T	P	R	R	--	--	0
Quadratic Equations (4)	29	T	R	--	R	--	--	0
	30	--	--	--	T	--	--	0
	31	--	--	--	T	--	--	0
	32	--	--	--	T	--	--	0

[a]Skill acquisition level ratings are based on responses made on a 3-point scale, where P = Prerequisite, R = Reviewed, and T = Taught.

[b]A dash is used to indicate no fleet usage.

[c]X = Yes and 0 = No.

Table A-1 (Continued)

Topic Area	Skill	Skill Acquisition Level Ratings[a] BE/E School	"A" Schools AE	"A" Schools AV	"C" Schools	Fleet[b] Usage AE	Fleet[b] Usage AV	Problems with[c] Level of Instruction
Algebraic Expressions (9)	33	--	--	--	R	--	--	X
	34	--	--	--	R	--	--	X
	35	--	--	--	R	--	--	X
	36	--	--	--	R	--	--	X
	37	--	--	--	R	--	--	X
	38	--	--	--	R	--	--	X
	39	--	--	--	R	--	--	X
	40	--	--	--	R	--	--	X
	41	--	--	--	R	--	--	X
Determinants (2)	42	--	--	--	T	--	--	0
	43	--	--	--	T	--	--	0
Geometry (2)	44	--	--	--	T	--	--	0
	45	P	--	--	T	--	--	X
Trigonometry (6)	46	T	R	--	T	--	--	X
	47	T	--	--	T	--	--	X
	48	--	--	--	--	--	--	0
	49	--	--	--	T	--	--	0
	50	--	--	--	T	--	--	0
	51	--	--	--	T	--	--	0
Phasors (7)	52	--	--	--	T	--	--	0
	53	--	--	--	R	--	--	X
	54	--	--	--	T	--	--	0
	55	--	--	--	T	--	--	0
	56	--	--	--	T	--	--	0
	57	--	--	--	T	--	--	0
	58	--	--	--	T	--	--	0
Number Bases (4)	59	--	T	T	T	--	--	X
	60	--	T	T	T	--	--	X
	61	--	T	T	T	--	--	X
	62	--	T	T	T	--	--	X
Boolean Algebra (8)	63	--	T	R	T	--	--	X
	64	--	T	R	T	--	Freq.	X
	65	--	T	R	T	--	--	X
	66	--	--	R	T	--	--	X
	67	--	T	R	T	--	--	X
	68	--	--	--	--	--	--	0
	69	--	T	R	T	--	--	X
	70	--	T	R	T	--	--	X

[a]Skill acquisition level ratings are based on responses made on a 3-point scale, where P = Prerequisite, R = Reviewed, and T = Taught.

[b]A dash is used to indicate no fleet usage.

[c]X = Yes and 0 = No.

Table A-2

Mathematical Requirements Associated with Schools Included in Training Sequence for CE Rating

Topic Area	Skill	Skill Acquisition Level Ratings[a] BE/E School	"A" Schools CE Gulfport	"A" Schools CE Port Hueneme	"C" Schools CE Gulfport	"C" Schools CE Port Hueneme	Fleet[b] Usage	Problems with[c] Level of Instruction
Arithmetic Operations with Numbers (4)	1	P	P	P	R	P	Freq.	X
	2	P	P	R	T	T	--	X
	3	--	--	--	T	T	Rarely	O
	4	R	P	R	R	P	Freq.	X
Estimations (1)	5	--	--	P	--	R	Freq.	X
Fractions (5)	6	P	P	R	R	T	Freq.	X
	7	P	P	R	R	R	--	X
	8	--	--	--	T	P	--	X
	9	P	P	R	R	R	--	X
	10	R	--	--	R	R	--	X
Units (4)	11	T	R	P	T	R	Rarely	X
	12	T	P	P	T	R	--	X
	13	T	P	P	--	T	--	X
	14	--	--	--	--	T	--	O
Conversions (3)	15	--	--	--	--	P	Rarely	X
	16	T	P	P	P	T	--	X
	17	--	P	--	--	R	--	X
Scientific Notation (4)	18	T	--	R	T	--	--	X
	19	T	--	R	T	--	--	X
	20	T	--	R	T	R	--	X
	21	T	--	--	--	--	--	O
Decibels (1)	22	--	--	--	--	--	--	O
Logarithms (4)	23	--	--	--	T	--	--	O
	24	--	--	--	T	--	--	O
	25	--	--	--	--	--	--	O
	26	--	--	--	--	--	--	O
Linear Equations (2)	27	T	P	R	T	T	--	X
	28	T	P	R	T	T	--	X
Quadratic Equations (4)	29	T	--	--	T	T	--	X
	30	--	--	--	--	--	--	O
	31	--	--	--	--	--	--	O
	32	--	--	--	--	--	--	O

[a]Skill acquisition level ratings are based on responses made on a 3-point scale, where P = Prerequisite, R = Reviewed, and T = Taught.

[b]A dash is used to indicate no fleet usage.

[c]X = Yes and O = No.

Table A-2 (Continued)

Topic Area	Skill	Skill Acquisition Level Ratings[a]					Fleet[b] Usage	Problems with[c] Level of Instruction
		BE/E School	"A" Schools		"C" Schools			
			CE Gulf-port	CE Port Hueneme	CE Gulf-port	CE Port Hueneme		
Algebraic Expressions (9)	33	--	--	--	--	T	--	0
	34	--	--	--	--	--	--	0
	35	--	--	--	--	--	--	0
	36	--	--	--	--	--	--	0
	37	--	--	--	--	--	--	0
	38	--	--	--	--	--	--	0
	39	--	--	--	--	--	--	0
	40	--	--	--	--	--	--	0
	41	--	--	--	--	--	--	0
Determinants (2)	42	--	--	--	--	--	--	0
	43	--	--	--	--	--	--	0
Geometry (2)	44	--	--	--	T	--	--	0
	45	P	P	T	T	T	--	X
Trigonometry (6)	46	T	--	--	T	T	--	X
	47	T	--	--	T	T	--	X
	48	--	--	--	--	--	--	0
	49	--	--	--	T	--	--	0
	50	--	--	--	--	--	--	0
	51	--	--	--	--	--	--	0
Phasors (7)	52	--	--	--	T	--	--	0
	53	--	--	--	T	--	--	0
	54	--	--	--	T	--	--	0
	55	--	--	--	T	--	--	0
	56	--	--	--	T	--	--	0
	57	--	--	--	T	--	--	0
	58	--	--	--	T	--	--	0
Number Bases (4)	59	--	--	--	--	--	--	0
	60	--	--	--	--	--	--	0
	61	--	--	--	--	--	--	0
	62	--	--	--	--	--	--	0
Boolean Algebra (8)	63	--	--	--	--	--	Rarely	0
	64	--	--	--	--	--	--	0
	65	--	--	--	--	--	--	0
	66	--	--	--	--	--	--	0
	67	--	--	--	--	--	--	0
	68	--	--	--	--	--	--	0
	69	--	--	--	--	--	--	0
	70	--	--	--	--	--	--	0

[a]Skill acquisition level ratings are based on responses made on a 3-point scale, where P = Prerequisite, R = Reviewed, and T = Taught.

[b]A dash is used to indicate no fleet usage.

[c]X = Yes and 0 = No.

Table A-3

Mathematical Requirements Associated with Schools
Included In Training Sequence for DS Rating

Topic Area	Skill	Skill Acquisition Level Ratings[a] BE/E School	"A" School	"C" Schools UYK-7	642A/B	Trans.	SYA-4	Periph.	Fleet[b] Usage	Problems with[c] Level of Instruction
Arithmetic	1	P	R	R	P	P	P	P	Freq.	X
Operations	2	P	--	R	R	P	P	P	--	X
with Numbers	3	--	R	P	--	--	P	--	--	X
(4)	4	R	--	--	--	P	P	--	--	X
Estimations (1)	5	--	R	--	--	P	--	--	--	X
Fractions (5)	6	P	--	P	--	P	P	P	--	X
	7	P	--	--	--	P	P	--	--	X
	8	--	--	--	--	--	P	--	--	X
	9	P	--	--	--	P	P	--	--	X
	10	R	--	--	--	--	P	--	--	X
Units (4)	11	T	P	--	P	P	P	P	Freq.	0
	12	T	P	R	P	P	P	P	--	0
	13	T	P	P	P	--	P	P	--	0
	14	--	--	--	P	P	P	--	--	X
Conversions	15	--	--	--	--	--	P	P	Freq.	X
(3)	16	T	P	R	P	P	P	P	--	0
	17	--	--	--	--	--	P	--	--	X
Scientific	18	T	R	R	T	P	P	--	--	X
Notation (4)	19	T	R	R	T	P	P	--	--	X
	20	T	R	R	T	P	P	--	--	X
	21	T	--	--	T	--	P	--	--	X
Decibels (1)	22	--	--	--	--	T	--	--	--	0
Logarithms (4)	23	--	--	--	--	--	--	--	--	0
	24	--	--	--	--	--	--	--	--	0
	25	--	--	--	--	--	--	--	--	0
	26	--	--	--	--	--	--	--	--	0
Linear	27	T	--	P	--	P	P	P	--	0
Equations (2)	28	T	--	--	--	P	P	--	--	0
Quadratic	29	T	--	--	--	--	P	--	--	0
Equations (4)	30	--	--	P	--	--	P	--	--	X
	31	--	--	--	--	--	P	--	--	X
	32	--	--	--	--	--	P	--	--	X

[a]Skill acquisition level ratings are based on responses made on a 3-point scale, where P = Prerequisite, R = Reviewed, and T = Taught.

[b]A dash is used to indicate no fleet usage.

[c]X = Yes and 0 = No.

Table A-3 (Continued)

Topic Area	Skill	Skill Acquisition Level Ratings[a] BE/E School	"A" School	"C" Schools UYK-7	642A/B	Trans.	SYA-4	Periph.	Fleet[b] Usage	Problems with[c] Level of Instruction
Algebraic Expressions (9)	33	--	--	--	--	--	P	--	--	X
	34	--	--	--	--	--	P	--	--	X
	35	--	--	--	--	--	P	--	--	X
	36	--	--	--	--	--	P	--	--	X
	37	--	--	--	--	--	P	--	--	X
	38	--	--	--	--	--	P	--	--	X
	39	--	--	--	--	--	P	--	--	X
	40	--	--	--	--	--	P	--	--	X
	41	--	--	--	--	--	P	--	--	X
Determinants (2)	42	--	--	--	--	--	P	--	--	X
	43	--	--	--	--	--	--	--	--	0
Geometry (2)	44	--	--	--	--	P	--	P	--	X
	45	P	--	--	--	R	--	P	--	X
Trigonometry (6)	46	T	--	--	--	P	--	R	--	0
	47	T	--	--	--	R	--	P	--	0
	48	--	--	--	--	--	--	P	--	X
	49	--	--	--	--	--	--	--	--	0
	50	--	--	--	--	--	--	T	--	0
	51	--	--	--	--	--	R	P	--	X
Phasors (7)	52	--	--	--	--	--	--	--	--	0
	53	--	--	--	--	--	--	--	--	0
	54	--	--	--	--	--	--	--	--	0
	55	--	--	--	--	--	--	--	--	0
	56	--	--	--	--	--	--	--	--	0
	57	--	--	--	--	--	--	--	--	0
	58	--	--	--	--	--	--	--	--	0
Number Bases (4)	59	--	T	R	P	P	P	P	Freq.	0
	60	--	T	R	P	P	P	P	--	0
	61	--	T	R	P	--	P	--	--	0
	62	--	T	R	P	P	P	--	--	0
Boolean Algebra (8)	63	--	T	R	P	P	P	P	Freq.	0
	64	--	T	R	P	P	P	P	--	0
	65	--	T	P	P	P	P	P	--	0
	66	--	T	P	P	P	P	P	--	0
	67	--	T	R	P	P	P	P	--	0
	68	--	T	R	P	--	P	P	--	0
	69	--	T	R	P	P	P	P	--	0
	70	--	T	R	P	P	P	P	--	0

[a]Skill acquisition level ratings are based on responses made on a 3-point scale, where P = Prerequisite, R = Reviewed, and T = Taught.

[b]A dash is used to indicate no fleet usage.

[c]X = Yes and 0 = No.

Table A-4

Mathematical Requirements Associated with Schools Included In Training Sequence for EM Rating

Topic Area	Skill	Acquisition Level Ratings[a] BE/E School	"A" School	"C" School	Fleet[b] Usage	Problems with[c] Level of Instruction
Arithmetic Operations with Numbers (4)	1	P	P	P	Freq.	X
	2	P	R	R	--	X
	3	--	--	R	--	X
	4	R	R	R	--	X
Estimations (1)	5	--	--	--	--	0
Fractions (5)	6	P	R	R	--	X
	7	P	R	R	--	X
	8	--	--	R	--	X
	9	P	P	R	--	X
	10	R	P	R	--	X
Units (4)	11	T	P	R	Freq.	0
	12	T	P	R	--	0
	13	T	P	R	--	0
	14	--	--	R	--	X
Conversions (3)	15	--	--	--	--	0
	16	T	P	R	--	0
	17	--	--	--	--	0
Scientific Notation (4)	18	T	R	R	--	0
	19	T	R	R	--	0
	20	T	--	R	--	0
	21	T	--	R	--	0
Decibels (1)	22	--	--	--	--	0
Logarithms (4)	23	--	--	--	--	0
	24	--	--	--	--	0
	25	--	--	--	--	0
	26	--	--	--	--	0
Linear Equations (2)	27	T	R	R	--	0
	28	T	R	R	--	0
Quadratic Equations (4)	29	T	R	R	--	0
	30	--	--	--	--	0
	31	--	--	--	--	0
	32	--	--	--	--	0

[a]Skill acquisition level ratings are based on responses made on a 3-point scale, where P = Prerequisite, R = Reviewed, and T = Taught.

[b]A dash is used to indicate no fleet usage.

[c]X = Yes and 0 = No.

Table A-4 (Continued)

Topic Area	Skill	Acquisition Level Ratings[a] BE/E School	"A" School	"C" School	Fleet[b] Usage	Problems with[c] Level of Instruction
Algebraic Expressions (9)	33	--	--	--	--	0
	34	--	--	--	--	0
	35	--	--	--	--	0
	36	--	--	--	--	0
	37	--	--	--	--	0
	38	--	--	--	--	0
	39	--	--	--	--	0
	40	--	--	--	--	0
	41	--	--	--	--	0
Determinants (2)	42	--	--	--	--	0
	43	--	--	--	--	0
Geometry (2)	44	--	--	--	--	0
	45	P	R	R	--	X
Trigonometry (6)	46	T	P	R	--	0
	47	T	--	R	--	0
	48	--	--	--	--	0
	49	--	--	--	--	0
	50	--	--	R	--	X
	51	--	--	--	--	0
Phasors (7)	52	--	--	--	--	0
	53	--	--	--	--	0
	54	--	--	--	--	0
	55	--	--	--	--	0
	56	--	--	--	--	0
	57	--	--	--	--	0
	58	--	--	--	--	0
Number Bases (4)	59	--	--	T	--	0
	60	--	--	T	--	0
	61	--	--	T	--	0
	62	--	--	T	--	0
Boolean Algebra (8)	63	--	--	T	--	0
	64	--	T	T	--	X
	65	--	--	T	--	0
	66	--	--	T	--	0
	67	--	--	T	--	0
	68	--	--	T	--	0
	69	--	--	T	--	0
	70	--	--	T	--	0

[a]Skill acquisition level ratings are based on responses made on a 3-point scale, where P = Prerequisite, R = Reviewed, and T = Taught.

[b]A dash is used to indicate no fleet usage.

[c]X = Yes and 0 = No.

Table A-5

Mathematical Requirements Associated with Schools
Included In Training Sequence for ET Rating

Topic Area	Skill	Acquisition Level Ratings[a] BE/E School	"A" School	"C" School	Fleet[b] Usage	Problems with[c] Level of Instruction
Arithmetic Operations with Numbers (4)	1	P	R	P	Freq.	X
	2	P	R	P	--	X
	3	--	--	P	--	X
	4	R	R	P	--	X
Estimations (1)	5	--	R	P	--	X
Fractions (5)	6	P	R	P	--	X
	7	P	--	P	--	X
	8	--	--	P	--	X
	9	P	--	P	--	X
	10	R	--	P	--	X
Units (4)	11	T	R	P	Freq.	0
	12	T	R	P	--	0
	13	T	R	P	--	0
	14	--	--	--	--	0
Conversions (3)	15	--	T	--	Freq.	0
	16	T	T	P	--	X
	17	--	T	P	--	0
Scientific Notation (4)	18	T	T	P	--	X
	19	T	T	P	--	X
	20	T	T	P	--	X
	21	T	T	--	--	X
Decibels (1)	22	--	T	P	Freq.	0
Logarithms (4)	23	--	--	--	--	0
	24	--	--	--	--	0
	25	--	--	--	--	0
	26	--	--	--	--	0
Linear Equations (2)	27	T	R	--	--	0
	28	T	R	--	--	0
Quadratic Equations (4)	29	T	R	--	--	0
	30	--	--	--		0
	31	--	--	--	--	0
	32	--	--	--	--	0

[a]Skill acquisition level ratings are based on responses made on a 3-point scale, where P = Prerequisite, R = Reviewed, and T = Taught.

[b]A dash is used to indicate no fleet usage.

[c]X = Yes and 0 = No.

Table A-5 (Continued)

Topic Area	Skill	Acquisition Level Ratings[a] BE/E School	"A" School	"C" School	Fleet[b] Usage	Problems with[c] Level of Instruction
Algebraic Expressions (9)	33	--	--	--	--	0
	34	--	--	--	--	0
	35	--	--	--	--	0
	36	--	--	--	--	0
	37	--	--	--	--	0
	38	--	--	--	--	0
	39	--	--	--	--	0
	40	--	--	--	--	0
	41	--	--	--	--	0
Determinants (2)	42	--	--	--	--	0
	43	--	--	--	--	0
Geometry (2)	44	--	--	--	--	0
	45	P	--	--	--	X
Trigonometry (6)	46	T	R	--	--	0
	47	T	--	--	--	0
	48	--	--	--	--	0
	49	--	--	--	--	0
	50	--	--	--	--	0
	51	--	--	--	--	0
Phasors (7)	52	--	--	--	--	0
	53	--	--	--	--	0
	54	--	--	--	--	0
	55	--	--	--	--	0
	56	--	--	--	--	0
	57	--	--	--	--	0
	58	--	--	--	--	0
Number Bases (4)	59	--	T	P	--	0
	60	--	T	R	--	0
	61	--	T	--	--	0
	62	--	--	R	--	X
Boolean Algebra (8)	63	--	T	R	--	0
	64	--	T	R	--	0
	65	--	T	R	--	0
	66	--	--	R	--	X
	67	--	T	R	--	0
	68	--	--	R	--	X
	69	--	T	R	--	0
	70	--	T	R	--	0

[a]Skill acquisition level ratings are based on responses made on a 3-point scale, where P = Prerequisite, R = Reviewed, and T = Taught.

[b]A dash is used to indicate no fleet usage.

[c]X = Yes and 0 = No.

Table A-6

Mathematical Requirements Associated with Schools Included In Training Sequence for EW Rating

Topic Area	Skill	Skill Acquisition Level Rating[a]							Fleet[b] Usage	Problems with[c] Level of Instruction
		BE/E School	"A" Schools[d]		"C" Schools					
			EWC	EWP	ULQ6C	WLR1IA	WLRIC	SLQ26		
Arithmetic Operations with Numbers (4)	1	P	R	R	P	P	P	P	Rarely	X
	2	P	R	--	R	P	P	R	--	X
	3	--	--	--	P	--	P	P	--	X
	4	R	R	R	R	P	P	R	--	X
Estimations (1)	5	--	--	--	P	P	P	P	--	X
Fractions (5)	6	P	R	R	--	P	P	--	--	X
	7	P	R	R	--	P	P	--	--	X
	8	--	R	--	--	P	P	--	--	X
	9	P	--	R	--	P	P	--	--	0
	10	R	R	R	--	P	P	--	--	X
Units (4)	11	T	R	R	--	P	P	--	Freq.	0
	12	T	R	R	--	P	P	--	--	0
	13	T	R	R	--	P	P	--	--	0
	14	--	R	R	--	P	P	--	--	X
Conversions (3)	15	--	--	--	--	P	--	--	--	X
	16	T	R	R	--	P	P	--	--	0
	17	--	R	R	--	P	--	--	--	X
Scientific Notation (4)	18	T	R	R	--	P	P	--	--	0
	19	T	R	R	--	P	P	--	--	0
	20	T	R	R	--	P	P	--	--	0
	21	T	R	R	--	P	P	--	--	0
Decibels (1)	22	--	T	T	--	P	P	--	Rarely	0
Logarithms (4)	23	--	T	T	--	P	R	--	--	0
	24	--	--	--	--	P	R	--	--	X
	25	--	T	T	--	P	R	--	--	0
	26	--	--	--	--	P	R	X	--	0
Linear Equations (2)	27	T	R	R	--	P	P	--	--	0
	28	T	R	R	--	P	P	--	--	0
Quadratic Equations (4)	29	T	R	R	--	P	P	--	--	0
	30	--	--	--	--	P	P	--	--	X
	31	--	--	--	--	P	P	--	--	X
	32	--	--	--	--	P	P	--	--	X

[a]Skill acquisition level ratings are based on responses made on a 3-point scale, where P = Prerequisite, R = Reviewed, and T = Taught.

[b]A dash is used to indicate no fleet usage.

[c]X = Yes and 0 = No.

[d]Data were obtained separately for the EW school's corrective and preventive maintenance sections (EWC and EWP) since the instruction and instructors were different.

Table A-6 (Continued)

Topic Area	Skill	Skill Acquisition Level Rating[a]							Fleet[b] Usage	Problems with[c] Level of Instruction
		BE/E School	"A" Schools[d]		"C" Schools					
			EWC	EWP	ULQ6C	WLR1A	WLRIC	SLQ26		
Algebraic Expressions (9)	33	--	--	--	--	P	P	--	--	X
	34	--	--	--	--	P	P	--	--	X
	35	--	--	--	--	P	P	--	--	X
	36	--	--	--	--	P	--	--	--	X
	37	--	--	--	--	P	--	--	--	X
	38	--	--	--	--	P	--	--	--	X
	39	--	--	--	--	P	--	--	--	X
	40	--	--	--	--	P	--	--	--	X
	41	--	--	--	--	P	--	--	--	X
Determinants (2)	42	--	--	--	--	--	--	--	--	X
	43	--	--	--	--	--	--	--	--	X
Geometry (2)	44	--	--	--	--	--	P	--	--	X
	45	P	--	--	--	--	P	--	--	X
Trigonometry (6)	46	T	R	--	--	--	P	--	--	0
	47	T	--	--	--	--	P	--	--	0
	48	--	--	--	--	--	P	--	--	X
	49	--	--	--	--	--	P	--	--	X
	50	--	--	--	--	--	P	--	--	X
	51	--	--	--	--	--	P	--	--	X
Phasors (7)	52	--	--	--	--	--	P	--	--	X
	53	--	--	--	--	--	--	--	--	0
	54	--	--	--	--	--	--	--	--	0
	55	--	--	--	--	--	--	--	--	0
	56	--	--	--	--	--	--	--	--	0
	57	--	--	--	--	--	--	--	--	0
	58	--	--	--	--	--	--	--	--	0
Number Bases (4)	59	--	T	--	--	--	P	--	--	0
	60	--	T	--	--	--	P	--	--	0
	61	--	T	--	--	--	P	--	--	0
	62	--	T	--	--	--	P	--	--	0
Boolean Algebra (8)	63	--	T	--	--	P	P	--	--	0
	64	--	T	--	--	P	P	--	--	0
	65	--	T	--	--	P	P	--	--	0
	66	--	--	--	--	P	P	--	--	X
	67	--	T	--	--	P	P	--	--	0
	68	--	--	--	--	P	P	--	--	X
	69	--	T	--	--	P	P	--	--	0
	70	--	T	--	--	P	P	--	--	0

[a]Skill acquisition level ratings are based on responses made on a 3-point scale, where P = Prerequisite, R = Reviewed, and T = Taught.

[b]A dash is used to indicate no fleet usage.

[c]X = Yes and 0 = No.

[d]Data were obtained separately for the EW school's corrective and preventive maintenance sections (EWC and EWP) since the instruction and instructors were different.

Table A-7

Mathematical Requirements Associated with Schools Included In Training Sequence for FT Rating

Topic Area	Skill	Skill Acquisition Level Rating[a] BE/E School	"A" Schools FTI	"A" Schools FTII	"C" Schools UYK-7	"C" Schools MK47	"C" Schools MK86	"C" Schools SPG53F	Fleet[b] Usage	Problems with[c] Level of Instruction
Arithmetic	1	P	R	P	P	P	P	P	Freq.	X
Operations	2	P	R	--	P	R	--	P	--	X
with Numbers	3	--	--	--	P	R	--	P	--	X
(4)	4	R	R	--	--	P	P	P	--	X
Estimations (1)	5	--	--	--	P	T	--	R	--	X
Fractions (5)	6	P	--	T	--	P	--	P	--	X
	7	P	--	T	--	P	P	P	--	X
	8	--	--	--	--	P	P	--	--	X
	9	P	--	R	--	P	--	--	--	X
	10	R	--	--	--	P	--	--	--	X
Units (4)	11	T	P	P	P	P	P	P	Freq.	0
	12	T	P	P	P	P	R	P	--	0
	13	T	P	P	P	P	R	P	--	0
	14	--	--	--	--	P	--	P	--	X
Conversions (3)	15	--	--	--	--	R	--	--	--	X
	16	T	R	R	--	P	R	P	--	0
	17	--	R	R	--	R	--	P	--	X
Scientific	18	T	R	R	R	R	--	P	--	0
Notation (4)	19	T	R	R	P	R	--	P	--	0
	20	T	P	P	P	R	--	P	--	0
	21	T	--	--	P	R	--	--	--	0
Decibels (1)	22	--	--	--	--	T	T	P	--	X
Logarithms (4)	23	--	--	--	--	--	T	--	--	0
	24	--	--	--	--	--	T	--	--	0
	25	--	--	--	--	--	T	--	--	0
	26	--	--	--	--	--	T	--	--	0
Linear Equa-	27	T	R	P	--	P	R	P	--	0
tions (2)	28	T	R	R	--	P	P	P	--	0
Quadratic	29	T	--	--	--	R	--	P	--	0
Equations (4)	30	--	--	--	--	R	--	--	--	X
	31	--	--	--	--	--	--	--	--	X
	32	--	--	--	--	--	--	--	--	X

[a]Skill acquisition level ratings are based on responses made on a 3-point scale, where P = Prerequisite, R = Reviewed, and T = Taught.

[b]A dash is used to indicate no fleet usage.

[c]X = Yes and 0 = No.

Table A-7 (Continued)

Topic Area	Skill	Skill Acquisition Level Rating[a]							Fleet[b] Usage	Problems with[c] Level of Instruction
		BE/E School	"A" Schools		"C" Schools					
			FTI	FTII	UYK-7	MK47	MK86	SPG53F		
Algebraic Expressions (9)	33	--	--	--	--	R	--	--	--	X
	34	--	--	--	--	T	--	--	--	0
	35	--	--	--	--	T	--	--	--	0
	36	--	--	--	--	T	--	--	--	0
	37	--	--	--	--	T	--	--	--	0
	38	--	--	--	--	--	--	--	--	0
	39	--	--	--	--	--	--	--	--	0
	40	--	--	--	--	--	--	--	--	0
	41	--	--	--	--	--	--	--	--	0
Determinants (2)	42	--	--	--	--	--	--	--	--	0
	43	--	--	--	--	--	--	--	--	0
Geometry (2)	44	--	--	T	--	--	R	P	--	0
	45	P	--	R	--	R	--	P	--	X
Trigonometry (6)	46	T	R	R	--	R	R	P	--	0
	47	T	R	R	--	R	--	P	--	0
	48	--	--	--	--	R	--	--	--	X
	49	--	--	--	--	R	R	P	--	X
	50	--	--	--	--	--	--	--	--	0
	51	--	--	--	--	--	R	--	--	X
Phasors (7)	52	--	T	--	--	--	--	--	--	0
	53	--	--	--	--	--	--	--	--	0
	54	--	R	--	--	--	--	--	--	X
	55	--	R	--	--	--	--	--	--	X
	56	--	--	--	--	--	--	--	--	0
	57	--	--	--	--	--	--	--	--	0
	58	--	--	--	--	--	--	--	--	0
Number Bases (4)	59	--	--	T	R	--	P	P	--	0
	60	--	--	T	R	--	P	P	--	0
	61	--	--	T	R	--	P	P	--	0
	62	--	--	T	R	--	P	--	--	0
Boolean Algebra (8)	63	--	--	T	R	--	P	P	--	0
	64	--	--	T	R	--	P	P	--	0
	65	--	--	T	R	--	P	--	--	0
	66	--	--	--	R	--	P	--	--	X
	67	--	--	T	R	--	P	P	--	0
	68	--	--	--	R	--	P	--	--	X
	69	--	--	T	R	--	P	P	--	0
	70	--	--	T	R	--	P	R	--	0

[a]Skill acquisition level ratings are based on responses made on a 3-point scale, where P = Prerequisite, R = Reviewed, and T = Taught.

[b]A dash is used to indicate no fleet usage.

[c]X = Yes and 0 = No.

Table A-8

Mathematical Requirements Associated with Schools
Included In Training Sequence for GM Rating

Topic Area	Skill	Skill Acquisition Level Rating[a] BE/E School	"A" School	"C" Schools MK45	MK10	MK42	MK11	MK16	Fleet[b] Usage	Problems with[c] Level of Instruction
Arithmetic	1	P	P	P	P	P	--	P	Freq.	X
Operations	2	P	R	--	--	--	--	--	--	X
with Numbers	3	--	--	--	--	--	--	--	--	0
(4)	4	R	R	--	--	P	--	P	--	X
Estimations (1)	5	--	--	--	--	--	--	--	--	0
Fractions (5)	6	P	R	--	P	--	--	--	--	X
	7	P	R	--	--	--	--	--	--	X
	8	--	--	--	--	--	--	--	--	0
	9	P	R	--	P	--	--	--	--	X
	10	R	--	--	P	--	--	--	--	X
Units (4)	11	T	R	--	--	--	--	--	--	0
	12	T	P	--	P	--	--	P	--	0
	13	T	R	--	P	--	--	--	--	0
	14	--	R	--	--	--	--	--	--	X
Conversions (3)	15	--	--	--	--	--	--	--	--	0
	16	T	--	P	P	--	--	--	--	0
	17	--	T	--	P	--	--	--	--	0
Scientific	18	T	--	--	P	--	--	--	--	0
Notation (4)	19	T	--	--	P	--	--	--	--	0
	20	T	--	--	P	--	--	--	--	0
	21	T	--	--	--	--	--	--	--	0
Decibels (1)	22	--	--	--	--	--	--	--	--	0
Logarithms (4)	23	--	--	--	--	--	--	--	--	0
	24	--	--	--	--	--	--	--	--	0
	25	--	--	--	--	--	--	--	--	0
	26	--	--	--	--	--	--	--	--	0
Linear Equations	27	--	--	--	--	--	--	--	--	0
(2)	28	--	--	--	--	--	--	--	--	0
Quadratic	29	--	--	--	--	--	--	--	--	0
Equations (4)	30	--	--	--	--	--	--	--	--	0
	31	--	--	--	--	--	--	--	--	0
	32	--	--	--	--	--	--	--	--	0

[a] Skill acquisition level ratings are based on responses made on a 3-point scale, where P = Prerequisite, R = Reviewed, and T = Taught.

[b] A dash is used to indicate no fleet usage.

[c] X = Yes and 0 = No.

Table A-8 (Continued)

Topic Area	Skill	Skill Acquisition Level Rating[a]							Fleet[b] Usage	Problems with[c] Level of Instruction
		BE/E School	"A" School	"C" Schools						
				MK45	MK10	MK42	MK11	MK16		
Algebraic Expressions (9)	33	T	P	--	P	--	--	--	--	0
	34	T	T	--	P	--	--	--	--	X
	35	T	T	--	P	--	--	--	--	X
	36	--	--	--	P	--	--	--	--	X
	37	--	--	--	--	--	--	--	--	0
	38	--	--	--	--	--	--	--	--	0
	39	--	--	--	--	--	--	--	--	0
	40	--	--	--	--	--	--	--	--	0
	41	--	--	--	--	--	--	--	--	0
Determinants (2)	42	--	--	--	--	--	--	--	--	0
	43	--	--	--	--	--	--	--	--	0
Geometry (2)	44	--	--	--	P	--	--	--	--	X
	45	P	--	--	--	--	--	--	--	X
Trigonometry (6)	46	T	--	--	--	--	--	--	--	0
	47	T	--	--	--	--	--	--	--	0
	48	--	--	--	--	--	--	--	--	0
	49	--	--	--	--	--	--	--	--	0
	50	--	--	--	--	--	--	--	--	0
	51	--	--	--	--	--	--	--	--	0
Phasors (7)	52	--	--	--	--	--	--	--	--	0
	53	--	--	--	--	--	--	--	--	0
	54	--	--	--	--	--	--	--	--	0
	55	--	--	--	--	--	--	--	--	0
	56	--	--	--	--	--	--	--	--	0
	57	--	--	--	--	--	--	--	--	0
	58	--	--	--	--	--	--	--	--	0
Number Bases (4)	59	--	--	--	--	--	--	--	--	0
	60	--	--	--	--	--	--	--	--	0
	61	--	--	--	--	--	--	--	--	0
	62	--	--	--	--	--	--	--	--	0
Boolean Algebra (8)	63	--	T	--	--	--	--	P	--	0
	64	--	T	--	--	--	P	P	--	0
	65	--	T	--	--	--	--	P	--	0
	66	--	--	--	--	--	--	P	--	X
	67	--	T	--	--	--	--	P	--	0
	68	--	--	--	--	--	--	P	--	X
	69	--	--	--	--	--	--	P	--	X
	70	--	--	--	--	--	P	P	--	X

[a]Skill acquisition level ratings are based on responses made on a 3-point scale, where P = Prerequisite, R = Reviewed, and T = Taught.

[b]A dash is used to indicate no fleet usage.

[c]X = Yes and 0 = No.

Table A-9

Mathematical Requirements Associated with Schools Included In Training Sequence for ST Rating

Topic Area	Skill	Skill Acquisition Level Rating[a] BE/E School	"A" School	"C" Schools MK114	ANSQ553	MK111	26CX	Fleet[b] Usage	Problems with[c] Level of Instruction
Arithmetic	1	P	P	P	P	P	P	Freq.	X
Operations	2	P	P	--	R	R	P	--	X
with Numbers	3	--	--	--	R	R	P	--	X
(4)	4	R	P	--	R	--	P	--	X
Estimations (1)	5	--	P	--	T	--	--	--	X
Fractions (5)	6	P	P	--	--	--	--	--	X
	7	P	P	--	--	--	--	--	X
	8	--	--	--	--	--	--	--	X
	9	P	P	--	--	--	--	--	X
	10	R	--	--	--	--	--	--	X
Units (4)	11	T	P	P	R	R	P	--	0
	12	T	P	--	R	--	P	--	0
	13	T	P	P	R	R	--	--	0
	14	--	P	--	--	--	--	--	X
Conversions (3)	15	--	--	--	--	--	--	Freq.	0
	16	T	P	P	R	R	R	--	0
	17	--	--	P	R	--	R	--	X
Scientific	18	T	P	--	R	R	R	--	0
Notation (4)	19	T	P	--	--	R	--	--	0
	20	T	P	--	--	R	R	--	0
	21	T	P	--	--	--	--	--	0
Decibels (1)	22	--	T	--	R	--	--	Freq.	0
Logarithms (4)	23	--	T	--	--	--	--	--	0
	24	--	T	--	--	--	--	--	0
	25	--	T	--	--	--	--	--	0
	26	--	--	--	--	--	--	--	0
Linear Equations	27	T	P	R	R	--	P	--	0
(2)	28	T	P	R	R	--	--	--	0
Quadratic	29	T	P	--	T	--	--	--	0
Equations (4)	30	--	--	--	--	--	--	--	0
	31	--	T	--	--	--	--	--	0
	32	--	--	--	--	--	--	--	0

[a]Skill acquisition level ratings are based on responses made on a 3-point scale, where P = Prerequisite, R = Reviewed, and T = Taught.

[b]A dash is used to indicate no fleet usage.

[c]X = Yes and 0 = No.

Table A-9 (Continued)

Topic Area	Skill	Skill Acquisition Level Rating[a]						Fleet[b] Usage	Problems with[c] Level of Instruction
		BE/E School	"A" School	"C" Schools					
				MK114	ANSQ553	MK111	26CX		
Algebraic Expressions (9)	33	--	P	R	P	--	P	--	X
	34	--	--	--	R	--	R	--	X
	35	--	P	--	--	--	R	--	X
	36	--	--	--	--	--	R	--	X
	37	--	--	--	R	--	R	--	X
	38	--	--	--	--	--	--	--	0
	39	--	--	--	--	--	--	--	0
	40	--	--	--	--	--	--	--	0
	41	--	--	--	--	--	--	--	0
Determinants (2)	42	--	--	--	--	--	--	--	0
	43	--	--	--	--	--	--	--	0
Geometry (2)	44	--	--	P	--	--	--	--	X
	45	P	--	R	R	T	R	--	X
Trigonometry (6)	46	T	R	R	R	T	P	--	X
	47	T	P	--	R	T	R	--	X
	48	--	--	--	--	--	--	--	0
	49	--	--	--	--	--	--	--	0
	50	--	--	--	R	--	--	--	X
	51	--	--	R	R	--	--	--	X
Phasors (7)	52	--	P	R	P	--	--	--	X
	53	--	--	--	--	--	--	--	0
	54	--	--	--	P	--	--	--	X
	55	--	--	--	P	--	--	--	X
	56	--	--	--	P	--	--	--	X
	57	--	--	--	P	--	--	--	X
	58	--	--	--	--	--	--	--	0
Number Bases (4)	59	--	T	T	R	R	T	--	X
	60	--	T	--	P	T	T	--	X
	61	--	T	--	--	T	--	--	X
	62	--	T	--	R	T	T	--	X
Boolean Algebra (8)	63	--	T	T	T	T	R	--	X
	64	--	T	T	T	T	R	--	X
	65	--	T	--	T	T	R	--	X
	66	--	T	T	--	T	--	--	X
	67	--	T	T	P	T	R	--	X
	68	--	T	--	--	T	R	--	X
	69	--	T	--	--	T	--	--	X
	70	--	T	--	T	T	--	--	X

[a]Skill acquisition level ratings are based on responses made on a 3-point scale, where P = Prerequisite, R = Reviewed, and T = Taught.

[b]A dash is used to indicate no fleet usage.

[c]X = Yes and 0 = No.

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